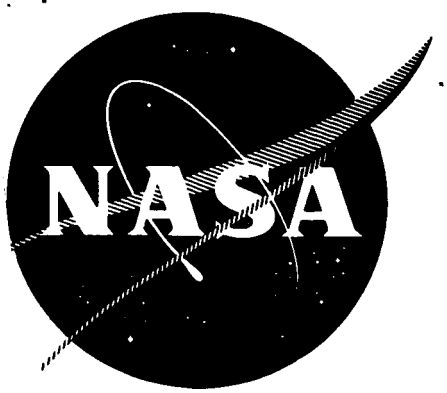

EVALUATION PROGRAM

for

SECONDARY SPACECRAFT CELLS

ACCEPTANCE TEST
OF
SONOTONE CORPORATION
3.0 AMPERE–HOUR TRIPLE SEAL
NICKEL CADMIUM CELLS

prepared for
GODDARD SPACE FLIGHT CENTER

CONTRACT W11,252B

QUALITY EVALUATION LABORATORY

NAD CRANE, INDIANA

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UNITED STATES NAVAL AMMUNITION DEPOT
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NICKEL CADMIUM CELLS

QE/C 65-512 23 July 1965

PREPARED UNDER THE DIRECTION OF

E. C. Bruess

E. C. BRUESS
Manager, Electrochemical
Power Sources Branch

APPROVED BY

E. R. PETTEBONE
COMMANDING OFFICER

V. YEAGER
By direction

Enclosure (1)

REPORT BRIEF

SONOTONE THREE AMPERE-HOUR NICKEL CADMIUM SECONDARY SPACECRAFT CELLS

Ref: (a) National Aeronautics and Space Administration Purchase Order Number W11,252B
(b) NASA ltr BRA/VBK/pad of 25 September 1961 w/BUWEPS first end FQ-1:WSK of 2 October 1961 to CO NAD Crane
(c) Preliminary Work Statement for Battery Evaluation Program of 25 August 1961

I. TEST ASSIGNMENT BRIEF.

A. In compliance with references (a) and (b), evaluation of Sonotone Corporation three ampere-hour nickel cadmium secondary spacecraft cells was begun according to the program outline of reference (c).

B. The object of this evaluation program is to gather specific information concerning secondary spacecraft cells. Information concerning performance characteristics and limitations, including cycle life under various electrical and environmental conditions, will be of interest to power systems designers and users. Cell weaknesses, including causes of failure of present designs, will be of interest to suppliers as a guide to product improvement.

C. Thirty cells were purchased from Sonotone Corporation, Elmsford, New York, by National Aeronautics and Space Administration (NASA). These cells are rated at three ampere-hours by the manufacturer and incorporate a triple seal technique.

II. CONCLUSIONS.

A. From the results of this test, it can be concluded that:

1. The triple seal technique, a ceramic seal between two glass to metal seals, manufactured by Sonotone Corporation is satisfactory as evidenced by no leakers out of the 30 cells tested.

2. The capacity of the cells was in the acceptable range of 3.05 to 4.16 ampere-hours.

III. RECOMMENDATIONS.

A. It is recommended that these Sonotone 3.0 ampere-hour triple-seal cells be accepted on the basis of the acceptance test results.

RESULTS OF ACCEPTANCE TESTS

OF

3.0 AMPERE-HOUR TRIPLE SEAL NICKEL CADMIUM SECONDARY SPACECRAFT CELLS

MANUFACTURED BY

SONOTONE CORPORATION

I. INTRODUCTION.

A. On 20 April 1965, this activity began acceptance tests on 30 cells. These tests were completed on 22 June 1965.

II. TEST CONDITIONS.

A. All acceptance tests were performed at an ambient temperature between 23° C and 27° C at existing relative humidity and atmospheric pressure, and consisted of the following:

1. Phenolphthalein Leak Test.
2. Capacity Test.
3. Cell Short Test.
4. Immersion Seal Test.
5. Overcharge Test.
6. Internal Resistance Test.
7. Immersion Seal Test.

B. All charging and discharging was done at constant current (± 5 percent). Cells were charged in series but discharged individually.

III. CELL IDENTIFICATION AND DESCRIPTION.

A. The cells were identified by the manufacturer's serial numbers which were from A3529 to A3567, although not consecutively.

B. The three ampere-hour "D" cell is cylindrical with an average diameter of 1.301 inches and an average overall length of 2.635 inches including the positive terminal. The average weight was 151.3 grams. Figure 1 is a photograph of a Sonotone Corporation three ampere-hour "D" cell.

C. The cell container or can, and the cell cover are made of stainless steel. Two stainless steel tabs, welded to the cover, serve as the contacts for the negative terminal. The positive terminal is solder type extension of the positive plate tab through the center of the cover. The positive terminal is insulated from the "negative" cover by a ceramic seal between two glass to metal seals to form a triple seal. Two crimp rings, about 1/32 inch deep, located about 1/2 inch from each end of the cell, were crimped after assembly to hold the element snugly in the can to withstand vibration.

D. These cells, rated by the manufacturer at three ampere-hours, were received in a partially discharged condition.

IV. TEST PROCEDURE AND RESULTS.

A. Phenolphthalein Leak Test:

1. The phenolphthalein leak test is a determination of the condition of the welds and ceramic seal on receipt of the cells. The test was performed prior to any other tests using a phenolphthalein spray indicator solution of one-half of one percent concentration.

2. There were no signs of leakage on any of the 30 cells subjected to the leak test.

B. Capacity Test:

1. The capacity test is a determination of the cell capacity at the c/2 discharge rate, where c is the manufacturer's rated capacity to a cutoff voltage of 1.00 volt per cell. The discharge was made after a 1-hour open circuit period following the 16-hour charge at the c/10 rate. A total of three capacity checks were made at this activity. The cells were discharged individually, but were recharged in series.

2. Since no capacity data was submitted by the manufacturer, it was not possible to compare the manufacturer's capacity values with those of this activity. The individual cell capacities ranged from 3.05 to 4.16 ampere-hours for an average of 3.50 ampere-hours to 1.00 volt. The cell capacities are tabulated in Table I. Characteristic 2-hour rate discharge curves are shown in Figure 3.

C. Cell Short Test:

1. The cell short test is a means of detecting slight shorting conditions which may exist because of imperfections in the insulating materials, or damage to element in handling or assembly.

2. Following completion of the third capacity discharge test, each individual cell was loaded with a resistor of value giving a c/1 to c/5 discharge rate and allowed to stand 16 hours with the resistor acting as a shorting device. At the end of 16 hours, the resistors were removed and the cells were placed on open circuit stand for 24 hours. Any cell whose voltage did not recover to 1.15 volts or higher was rejected.

3. The open circuit cell voltages, 24 hours after removal of the shorting resistors, ranged from 1.16 to 1.20 volts for an average of 1.18 volts.

4. There were no rejects on any of the cells subjected to the cell short test. The voltage values for the 30 accepted cells are shown in Table I.

D. Immersion Seal Test:

1. The immersion seal test is a means of detecting leakage of a seal or weld. The test was performed before and after the overcharge test sequence to determine the presence and cause of leaks.

2. The cells were placed under water in a bell jar container. A vacuum of 20 inches of mercury was held for 3 minutes. Cells discharging a steady stream of bubbles were considered rejects.

3. There were no rejects in the 30 cells subjected to the immersion seal test.

E. Overcharge Test:

1. The overcharge tests were performed to determine the steady state voltage at specified rates. The test specified a series of constant current charges at c/20, c/10 and c/5 rates, for a minimum of 48 hours at each charge rate or until the increase of the "on-charge" voltage was less than 10 millivolts per day.

2. The cells were monitored hourly throughout the test. Charging was to be discontinued on cells which exceeded 1.50 volts while on charge. There was no need to remove any cells from the charging sequence.

3. The steady state voltage of each cell at the end of each 48-hour charge rate test is shown in Table I. Characteristic overcharge voltage curves are shown in Figure 3.

F. Internal Resistance Test:

1. This test was performed to determine the internal resistance of the cell.

2. At the completion of the overcharge test; the cells were returned to the c/20 charging rate and given a short pulse (5 to 10 seconds) at the rate of c in amperes. The cell voltages, V1, immediately prior to the pulse; and V2, 5 milliseconds after the pulse, were read on a suitable recording instrument. A CEC high speed oscillograph recorder (28.8 inches of tape per second) was used. The internal resistance of the cell in ohms was calculated according to the following formula:

$$R = \frac{V2 - V1}{Ic - Ic/20}$$

V1 and V2 are in volts, Ic and Ic/20 are in amperes.

3. The internal resistance value for each cell is shown in Table I. The values range from 3.7 milliohms to 7.4 milliohms.

TABLE I

CELL NUMBER	WEIGHT (GRAMS)	LENGTH (INCHES)	DIAMETER (INCHES)	CAPACITY TEST (A.H.)	CAPACITY TEST (A.H.)	CAPACITY TEST (A.H.)	CELL SHORT TEST (VOLTS)	IMMERSION SEAL TEST	OVERCHARGE c/20 (VOLTS)	OVERCHARGE c/10 (VOLTS)	OVERCHARGE c/5 (VOLTS)	INTERNAL RESISTANCE (MILLIOHMS)	IMMERSION SEAL TEST
A3529	153.5	2.635	1.303	3.66	3.26	3.46	1.18	O.K.	1.38	1.39	1.40	7.4	O.K.
A3530	149.5	2.670	1.300	3.84	3.66	3.76	1.18	O.K.	1.38	1.39	1.40	7.4	O.K.
A3531	149.5	2.647	1.300	3.76	3.46	3.60	1.18	O.K.	1.38	1.40	1.40	7.4	O.K.
A3532	151.5	2.624	1.300	3.86	3.56	3.80	1.20	O.K.	1.38	1.40	1.40	3.7	O.K.
A3533	158.0	2.640	1.305	4.16	3.96	4.14	1.20	O.K.	1.38	1.40	1.42	3.7	O.K.
A3534	147.5	2.625	1.300	3.66	3.34	3.50	1.18	O.K.	1.38	1.40	1.40	3.7	O.K.
A3535	147.0	2.630	1.300	3.66	3.04	3.26	1.18	O.K.	1.38	1.40	1.40	3.7	O.K.
A3536	154.0	2.625	1.307	3.66	3.26	3.36	1.18	O.K.	1.38	1.40	1.40	3.7	O.K.
A3537	145.5	2.619	1.294	3.46	3.20	3.34	1.17	O.K.	1.38	1.39	1.40	3.7	O.K.
A3541	148.0	2.635	1.296	3.40	3.26	3.34	1.17	O.K.	1.38	1.39	1.40	3.7	O.K.
A3543	152.5	2.632	1.300	3.90	3.66	3.80	1.18	O.K.	1.38	1.40	1.40	3.7	O.K.
A3544	151.5	2.680	1.305	3.34	3.10	3.20	1.18	O.K.	1.38	1.40	1.40	7.4	O.K.
A3545	152.5	2.611	1.304	3.46	3.24	3.40	1.18	O.K.	1.38	1.39	1.40	7.4	O.K.
A3546	149.5	2.630	1.300	3.66	3.24	3.34	1.16	O.K.	1.38	1.40	1.40	7.4	O.K.
A3549	154.0	2.653	1.304	3.50	3.14	3.30	1.17	O.K.	1.38	1.40	1.40	7.4	O.K.

TABLE I (Contd)

CELL NUMBER	WEIGHT (GRAMS)	LENGTH (INCHES)	DIAMETER (INCHES)	CAPACITY TEST (A.H.)	CAPACITY TEST (A.H.)	CAPACITY TEST (A.H.)	CELL SHORT TEST (VOLTS)	IMMERSION SEAL TEST	OVERCHARGE c/20 (VOLTS)	OVERCHARGE c/10 (VOLTS)	OVERCHARGE c/5 (VOLTS)	INTERNAL RESISTANCE (MILLIOHMS)	IMMERSION SEAL TEST
A3551	153.0	2.648	1.304	3.11	3.05	3.11	1.19	O.K.	1.39	1.40	1.42	7.4	O.K.
A3552	152.0	2.625	1.304	3.35	3.18	3.12	1.16	O.K.	1.40	1.40	1.42	7.4	O.K.
A3553	152.0	2.630	1.308	3.18	3.12	3.03	1.20	O.K.	1.39	1.40	1.41	3.7	O.K.
A3555	156.0	2.632	1.308	3.57	3.57	3.57	1.19	O.K.	1.40	1.41	1.44	3.7	O.K.
A3556	146.0	2.645	1.300	3.35	3.23	3.15	1.19	O.K.	1.39	1.40	1.42	7.4	O.K.
A3557	150.5	2.638	1.295	3.68	3.63	3.53	1.20	O.K.	1.40	1.41	1.43	7.4	O.K.
A3558	149.0	2.667	1.296	3.50	3.38	3.33	1.17	O.K.	1.39	1.40	1.42	3.7	O.K.
A3559	152.0	2.640	1.305	3.15	2.93	2.96	1.19	O.K.	1.40	1.41	1.43	3.7	O.K.
A3560	154.0	2.625	1.297	3.05	3.05	3.26	1.17	O.K.	1.40	1.40	1.42	3.7	O.K.
A3561	151.0	2.612	1.295	3.23	3.33	3.42	1.19	O.K.	1.39	1.40	1.42	3.7	O.K.
A3562	149.5	2.640	1.293	3.30	3.30	3.33	1.17	O.K.	1.40	1.40	1.42	7.4	O.K.
A3563	154.5	2.625	1.310	3.38	3.33	3.48	1.18	O.K.	1.40	1.41	1.43	7.4	O.K.
A3565	147.0	2.640	1.300	3.08	3.11	3.30	1.16	O.K.	1.40	1.41	1.42	3.7	O.K.
A3566	154.0	2.625	1.301	3.26	3.27	3.38	1.16	O.K.	1.40	1.41	1.43	3.7	O.K.
A3567	155.0	2.600	1.305	3.00	2.90	3.05	1.18	O.K.	1.39	1.40	1.42	3.7	O.K.

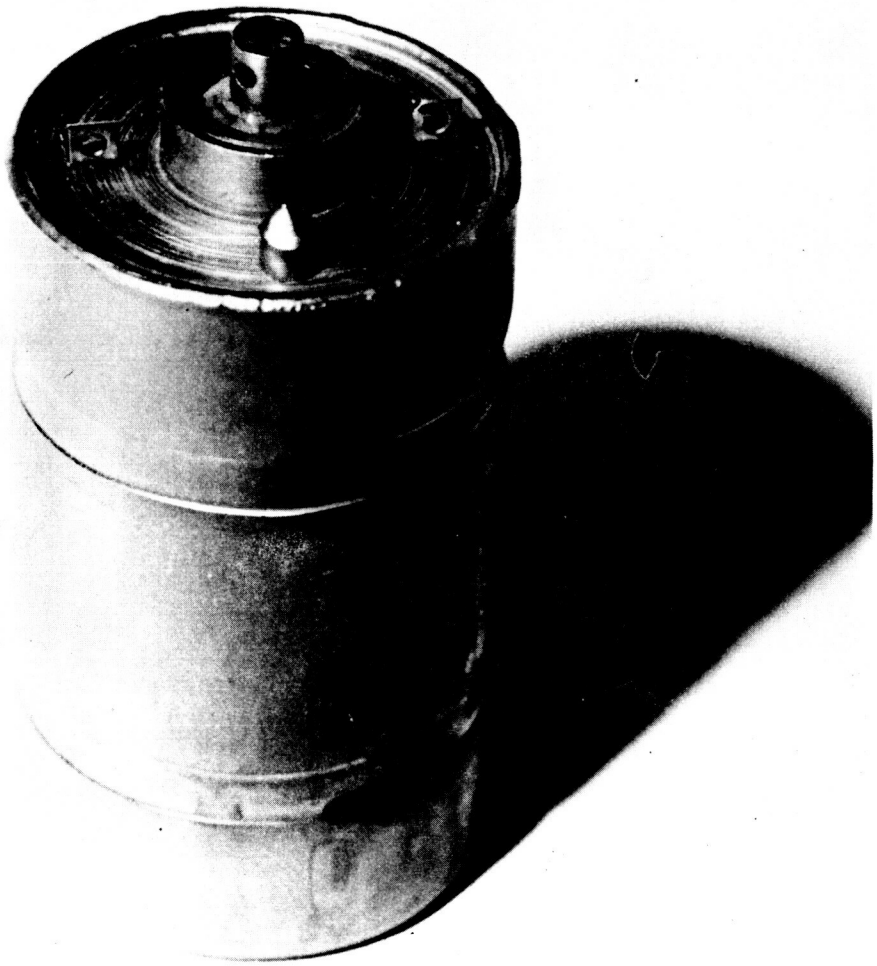
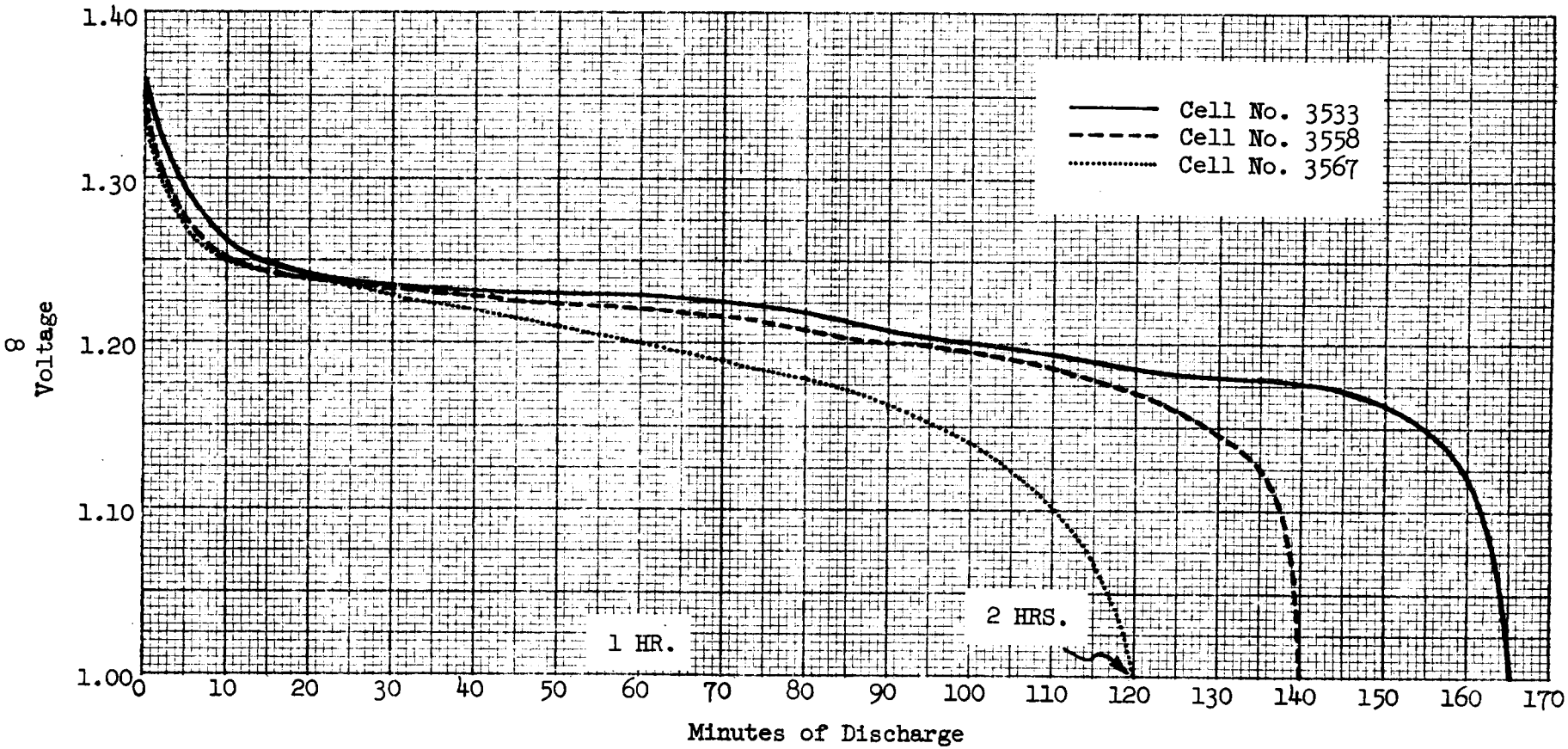


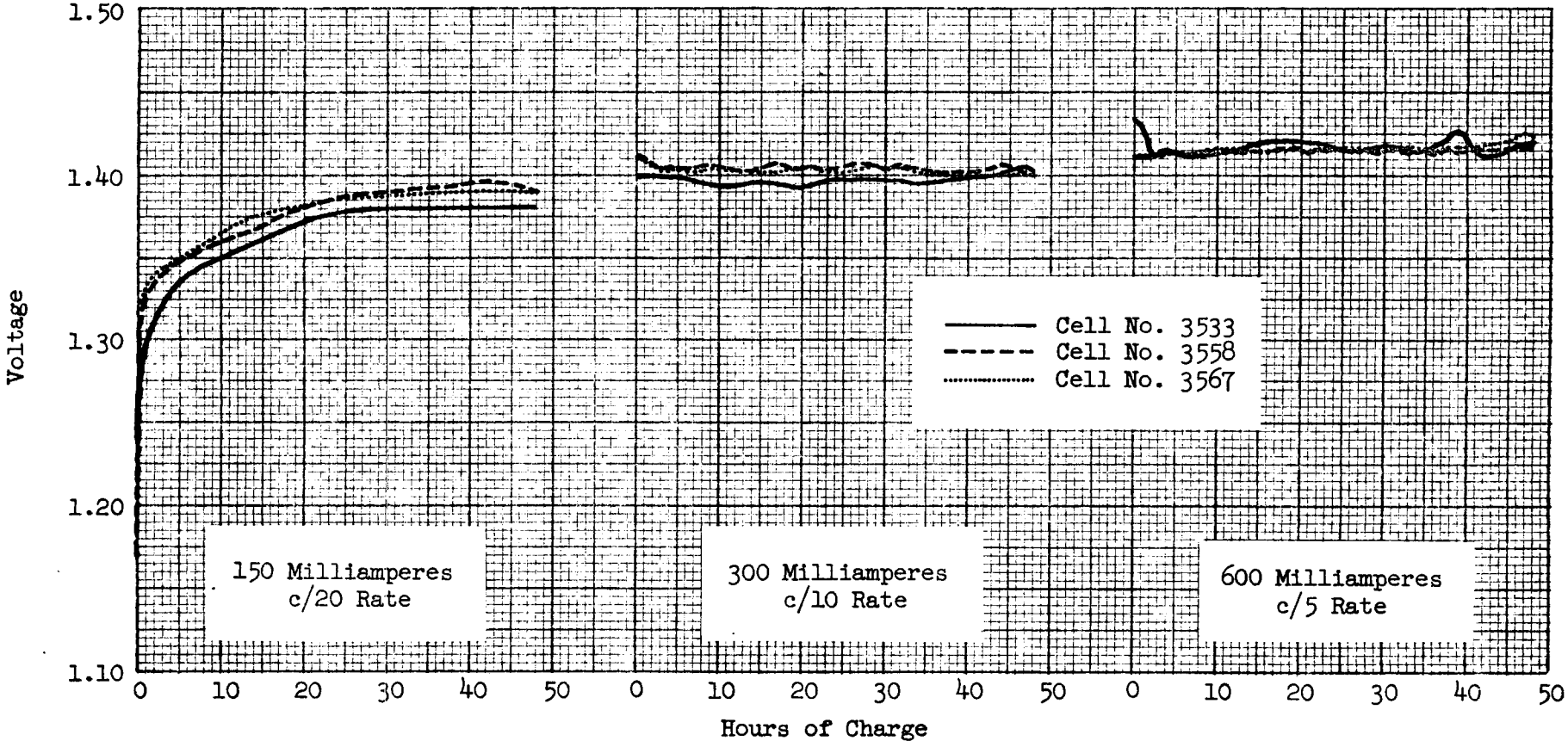
FIGURE 1



CHARACTERISTIC 2-HOUR RATE DISCHARGE CURVES

SONOTONE 3 AMPERE-HOUR NICKEL CADMIUM SEALED CELLS

FIGURE 2



CHARACTERISTIC 48-HOUR OVERCHARGE CURVES

SONOTONE 3 AMPERE-HOUR NICKEL CADMIUM SEALED CELLS

FIGURE 3